

# CLIVAR/CliC/SCAR Southern Ocean Region Panel SORP

## National activities report

Country : India  
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*Receipt of material prior to 15 June 2019 will ensure inclusion in meeting discussion.  
Receipt of material prior to 15 July 2019 will ensure inclusion in meeting report and contribute to future SORP discussions, as well as input to the SOOS and other CLIVAR/CliC/SCAR activities. All reports will be posted on the SORP website.*

- Purpose of material gathered for the SORP:

To build an overview of observational, modeling, national projects and initiatives, ocean reanalysis and state estimation initiatives relevant to the SORP

(This can be detailed as a list of activities; maps showing where instruments have been or will be deployed; examples of modeling developments, experiments and set-ups; major national and international project involvement; etc.)

- Please refer to SORP's terms of reference (also given at the end of this template) for guidance on scope: <http://www.clivar.org/clivar-panels/southern>

Note: Biological topics such as marine ecology research, for example, are not within the scope of SORP's terms of reference and are therefore not required in these reports. However, SOOS has an interest in such research, so National Representatives are encouraged to include summaries of such research as separate sections.

Note: The Southern Ocean is not explicitly defined in SORP's terms of reference, so please note what the limit used for your national report is (e.g., research on regions only beyond an oceanographic boundary like "south of the Polar Front", or research contained within latitudinal limits like "south of 50°S").

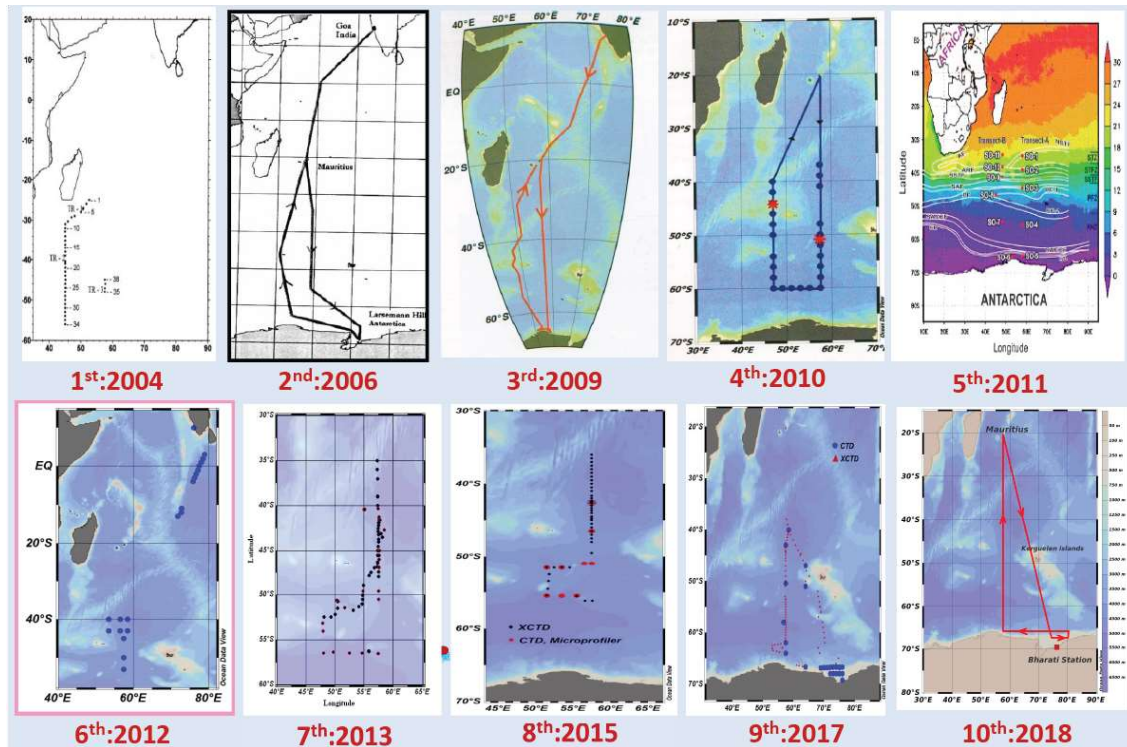
## Summary of National Activities

*(Half page max. This section should include a succinct list of the main annual activities and breakthroughs as well as future plans)*

*Annual activities:* Several studies have proved the unprecedented role of Southern Ocean (SO) in influencing the global climatic variability. However, the Indian sector of SO (ISSO; 40-69°S 40-90°E) is an under-explored region, where sparse data availability limit our knowledge of understanding the role of ISSO in the climatic variability. On this backdrop the Ministry of Earth Sciences (MoES), Govt. of India has initiated a National programme to systematically investigate the ISSO. Since 2004, under the aegis of MoES, concerted efforts are put in place by the nodal agency National Centre for Polar and Ocean Research (NCPOR), Goa to carryout detailed ecosystem surveys in ISSO to generate long term sea-truth data with the primary focus to comprehend “the role(response) of ISSO in(to) regional and global climate variability”. During the period 2004-2018, NCPOR has successfully undertaken 10 multi-institutional (including foreign researchers) and cross-disciplinary scientific expeditions in the ISSO (Figure 1) during the austral summer (December-March) covering the major disciplines of research such as hydrodynamics, biogeochemistry, air-sea interaction, lower atmospheric processes and palaeo-environmental studies. India’s research activities in the ISSO realm highlight importance of enhanced understanding of the hydrodynamics and biogeochemistry of the SO processes in relation to global climate change scenario.

*Breakthroughs:* Some of the salient findings obtained from the Indian SO Expeditions (ISOE) highlights (i) the southward meandering of ACC attributed to bottom topography, (ii) north-south movement of water masses due to the influence of eddies, (iii) zones of sink (52°S) and source (45°S) of CO<sub>2</sub>, (iv) glacier melting-induced freshening of the Antarctic Bottom Water, (v) dominance of non sea salt aerosols in the SO and (vi) melt-water influence on phytoplankton productivity in the coastal and open ocean etc. Based on the findings obtained from the ISOE ~70 research papers were published in peer-reviewed journals of national and international repute, including 2 special issues in the journal of *Current Science* (2010) and *Deep-Sea Research Part II: Topical Studies in Oceanography* (2015), and one more special issue is in pipeline. NCPOR have also national representatives in the international bodies like SOOS and SCAR. Under the GO-SHIP programme NCPOR has been identified to collect annual time series data along the 57.5 °E track in the SO.

*Future plans:* Since the ISOE are restricted to austral summer only, there is non-availability of sea-truth data during rest of the seasons. Though systematic samplings have been carried out at different frontal regions and coastal areas, it is still sparse and not sufficient to assess the climate change impacts. Thus, to bridge the gap of *in situ* data collection on oceanographic variables NCPOR is planning to acquire data of high spatiotemporal resolution that involve long-term, continuous observations using remotely operated platforms such as Argo floats, glider-based measurements, sediment-trap and air-sea flux moorings, mooring profilers in the coastal Antarctica, simulation/modeling and satellite remote sensing of different biogeochemical variables in the ISSO.



**Figure 1:** Cruise tracks of all the Indian Southern Ocean expeditions carried out till date. (the cruise tracks of each expedition were planned considering the logistical challenges and the extreme rough weather conditions encountered in the Southern Ocean)

## A. Recent and ongoing activities

If your country has a national committee tasked with oversight of Southern Ocean climate science (e.g., like US CLIVAR), please give the name of the committee.

YES. India has a National Coordination Committee on Polar Science Program (NCPSP), which reviews the polar programs and schedule of the annual Indian scientific expeditions to Antarctica, Arctic and Southern Ocean, as well as finalize the composition of the Indian scientific teams ensuring inter-institutional/ministerial co-operation.

Describe which major activities have been carried out in the last year or are in progress now. For each activity/project, provide a contact information (e.g., Principal Investigators and Associate Investigators), a website if available and a list of relevant publications.

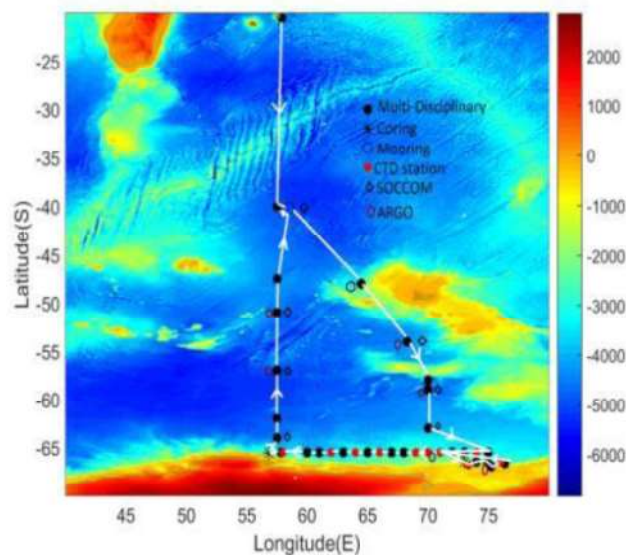
### 1. Observational Activities

Major activities carried out last year: During the year 2017-18 (December 9, 2017 to February 5, 2018), the 10<sup>th</sup> ISOE was successfully completed. The expedition team consisted of 42 participants from 9 different organizations including one participant from

the Scripps Institute of Oceanography, USA. The expedition started from Port Louis, Mauritius and witnessed measurement of cross-disciplinary parameters (physical, chemical, biological, optical, geological and atmospheric) from a total of 36 stations covering from 40°S to the coastal waters of Antarctica (67°S) onboard South African chartered research vessel *MV SA Agulhas* (Figure 2). The following studies were envisaged during the expedition:

- Studies on air-sea interaction, aerosol and atmospheric trace gases (halogens)
- Current structure and volume transport, water masses characteristics - AABW freshening).
- Plankton taxonomy and abundance
- Food web dynamics
- Primary productivity and bio-optical studies
- Coring operations - Palaeoclimatic studies
- Intensive sampling from Polar Front to coastal waters of Antarctica with more emphasis on the Prydz Bay area
- Deployment of ARGO, SOCCOM Floats were also carried out during the expedition

As per the cruise plan samples collection and observations were successfully carried out during the expedition (60 days) and analyses are under progress. Observations were carried out at all the frontal regions during the cruise and multidisciplinary measurements were carried out in those locations. In addition to this, the continuous measurement of atmospheric parameters of temperature, humidity, pressure, wind speed, wind direction, black carbon, trace gases, rainfall, water vapour and light along the cruise track were carried out for upper atmospheric observation, Air-sea interaction from tropical to Polar Regions to establish the link between climatic variability and biogeochemical cycling.



**Figure 2:** Cruise tracks showing sampling locations of ISOE-10 (2017-18)

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*Website information:* Research activities and list of relevant publications of Indian Southern Ocean Expeditions can be viewed through the below links:

- <http://www.ncaor.gov.in/pages/display/270-southern-ocean>
- <http://www.ncaor.gov.in/pages/researchview/16>

## 2. Modeling Activities

So far the ISOEs are basically focusing on in situ observations and remote sensing-based analysis to explain the variability in this sector of the SO. Modeling activities are yet to be started.

## 3. Ocean reanalysis and state estimation Activities

Activities on these aspects are in initial stage. Preliminary reanalysis of data on hydrodynamics is under process, whereas publications on expansion of sea-ice and occurrence of polynya in this sector are already available from NCPOR.

## 4. National and International Projects/Initiatives

Being a National programme, the ISOE involves participants from different organizations/universities from all over India who are interested in Polar Research. Besides it welcomes international participants too. Under the international collaboration researchers from Institute of Oceanography, FURG, Brazil, (5<sup>th</sup> ISOE, 2011), University of York, UK (9<sup>th</sup> ISOE, 2017), Scripps Institute of Oceanography, USA (10<sup>th</sup> ISOE, 2018) have participated.

## **Planned activities**

*List which major activities are planned or likely to occur during the next several years, together with a contact information (e.g., Principal Investigators and Associate Investigators).*

### 1. Observational

Links between processes in the ISSO and global climate variability is continued to be hampered by a dearth of long-term observations undertaken at different time and space scales. To bridge the gap the following observational initiatives are envisaged:

- Deployment of sediment-trap and air-sea flux mooring for collection of year round observations at one of the frontal regions in the ISSO.
- Deployment of underwater autonomous glider for collecting long-term, multidisciplinary observations.
- Profiler mooring in Pyrdz Bay for studying bottom water formation.

## 2. Modeling

Modeling aspects on the following activities are going to be implemented:

Sea –ice/Ocean modeling with atmospheric forcing  
Primary production and bio-optical parameters modeling and validation  
Modeling on distribution of phytoplankton group and validation

## 3. Ocean reanalysis and state estimation

Reanalysis of data will be carried out for better understanding of hydrodynamics and sea-ice dynamics.

## 4. National and International Projects/Initiatives

The Indian Southern Ocean program is a multi-institutional and multidisciplinary in nature including participation from national and international organizations/universities. Most of the projects under this programme are ongoing projects and the important findings from these projects are reported in peer-reviewed scientific journals of national and international repute. The ISOE would continue to work with all the collaborative partners from India and abroad and would welcome research proposals pertaining to Indian sector of Southern Ocean.

## **CLIVAR/CliC/SCAR SORP terms of reference**

(<http://www.clivar.org/clivar-panels/southern>)

*"To serve as a forum for the discussion and communication of scientific advances in the understanding of climate variability and change in the Southern Ocean. To advise CLIVAR, [CliC](#), and [SCAR](#) on progress, achievements, new opportunities and impediments in internationally-coordinated Southern Ocean research."*

### **Specific Activities:**

1. Facilitate progress in the development of tools and methods required to assess climate variability, climate change and climate predictability of the ocean-atmosphere-ice system in the Southern Ocean.
2. Identify opportunities and coordinated strategies to implement these methods, spanning observations, models, experiments, and process studies.
3. Provide scientific and technical input into international research coordination, collaborating as required with other relevant programs, including the [Southern Ocean Observing System \(SOOS\)](#).
4. Monitor and evaluate progress in Southern Ocean research, and identify gaps.
5. Enhance interaction between the meteorology, oceanography, cryosphere, geology, biogeochemistry and paleoclimate communities with an interest in the climate of the Southern Ocean.
6. Work with relevant agencies on the standardization, distribution and archiving of Southern Ocean observations.